Docket No.: 13077-00140-US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Friedrich Jonas et al.

Application No.: 10/057,027

Confirmation No.: 3582

Filed: January 24, 2002

Art Unit: 1712

For: ELECTROLUMINESCENT ARRANGEMENTS

Examiner: D. S. Metzmaier

SUBSTITUTE APPEAL BRIEF

MS Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

This brief is filed in response to the Notification of non-compliant Brief mailed September 7, 2007.

The fees required under § 41.20(b)(2) were submitted with the original TRANSMITTAL OF APPEAL BRIEF. However, if additional fees are due, please charge our Deposit Account No. 03-2775, under Order No. 13077-00140-US from which the undersigned is authorized to draw.

This brief contains items under the following headings as required by 37 C.F.R. § 41.37 and M.P.E.P. § 1205.2:

I.	Real Party In Interest
II	Related Appeals and Interferences
III.	Status of Claims
IV.	Status of Amendments
V.	Summary of Claimed Subject Matter
VI.	Grounds of Rejection to be Reviewed on Appeal
VII.	Argument
VIII.	Claims
Appendix A	Claims Appendix
Appendix B	Evidence Appendix
Appendix C	Related Proceedings Appendix

I. REAL PARTY IN INTEREST

The real party in interest for this appeal is:

H. C. Starck GmbH

II. RELATED APPEALS AND INTERFERENCES

There are no other appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

A. Total Number of Claims in Application

There are 4 claims pending in application.

B. Current Status of Claims

1. Claims canceled: 2, 3, and 6-8
2. Claims withdrawn from consideration but not canceled: 0
3. Claims pending: 1, 4, 5 and 9
4. Claims allowed: 0
5. Claims rejected: 1, 4, 5 and 9

C. Claims On Appeal

The claims on appeal are claims 1, 4, 5 and 9

IV. STATUS OF AMENDMENTS

Applicant did not file an Amendment After Final Rejection. Applicant did file a Request for Reconsideration which was considered by the Examiner pursuant to the Advisory action mailed February 20, 2007.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Claims 1, 4, 5 and 9 are subject to this appeal. There is only one independent claim (claim 1). All the claims stand or fall together. Support for claim 1 can be found in the brackets after each portion of the claim. Claim 1 states

A dispersion comprising:

polyanions;

cationic 3,4-polyalkyleriedioxythiophenes; **[see page 3, lines 15-17of the specification]** and

a solvent comprising water and optionally alcohol, **[see page 6, lines 10-12 of the specification]**

wherein said dispersion has a weight ratio of cationic 3,4-polyalkylene-dioxythiophene to polyanion of from 1: 8 to 1: 25, and **[see page 5, lines 11-19 and in particular lines 17-19 of the specification]**

90% by weight of the particles of the dispersion being less than 40 nm. **[see page 3, lines 29-30 of the specification**

[Also see the original claims 1, 2 and 6].

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 1, 4, 5 and 9 were rejected under 35 U.S.C. § 112, first paragraph, as based on a disclosure which does not have an adequate written description.

VII. ARGUMENT

The outstanding Official Action has rejected claims 1, 4, 5, and 9 under 35 U.S.C. § 112, first paragraph, as based on a disclosure which does not have an adequate written description. The Examiner asserted in the Advisory Action that "Applicants arguments are not deemed persuasive as they do not address that the subject matter is essential subject matter." The applicant respectfully disagrees.

The first step for preparing the applicant's dispersion is preparing a 3,4-polyethylenedloxythiophene/ polystyrene sulphonate dispersion in accordance with example 2 of EP 0991303. This is disclosed in all the examples (examples 1-3) of the applicant's specification. Furthermore, the applicant states at page 3, lines 10-13 of the specification

> Surprisingly, it has now been found that by further **<u>reducing the size of the particles</u>**, the <u>resistance of the 3,4-polyalkylenedioxythiophenes described in EP-A 991 303 can be significantly increased without the desired hole-injecting action being lost</u>. (Emphasis added)

This also confirms that the first step for preparing the applicant's dispersion is preparing a 3,4-polyethylenedloxythiophene/ polystyrene sulphonate dispersion in known by one of ordinary skill in the art and refers to EP 0991303.

Then additional steps are taken to prepare the applicant's inventive dispersion. A person skilled in the art would know how to make the dispersion according to the first step, i.e. example 2 of EP 0991 303 discloses the preparation of such a dispersion in <u>a known manner</u> -but a person skilled in the art would not know the additional steps for preparing the applicant's inventive dispersion.

The applicant stated in the middle of page 4 of their response filed on September 9, 2004:

> One having ordinary skill in the art would not know how to make the [applicant's claimed invention] dispersion comprising polyanions and cationic 3,4-polyalkylenedioxythiophenes and water or a water/alcohol mixtures as a solvent, wherein about 90% of the particles of the dispersion are less than 50 nm and wherein the resistivity of the coating produced therefrom by building a dispersion film and removing the solvent from the dispersion filim is at least 5000Ωcm, wherein the weight ratio of cationic 3,4-polyalkylene-dioxythiophene to polyanion have a ratio ranging from between about 1:8 and about 1:25 and which was treated by high pressure homogenization applying a pressure from 100 to 1000 bar of Applicants' invention.
>
> To establish that "one skilled in the art would have known how to make" Applicants' invention, the Examiner must establish a prima facie case of obviousness....

In the final Office Action at page 2, the Examiner stated,

> Applicants (page 4 of the response filed September 9, 2004) state that one having ordinary skill in the art would **not** know how to make the claimed dispersions and further state that the examiner has not provided a *prima facie* case of obviousness regarding the making of the poly (3,4-polyalkylenedioxythiophene.

As can be seen from the actual quote above, the Examiner cites parts of the above response in a wrong way. EP 0991 303 does not disclose the preparation of the applicant's dispersion, but it describes — as mentioned above — the preparation of a "basic dispersion", which is the first step to make the applicant's claimed inventive dispersion. As already pointed out a person of ordinary skill in the art would know how to make this 'basic dispersion". The additional steps which are necessary to prepare the applicant's inventive dispersion are described in the examples of the patent application.

Therefore, the argument of the Examiner that the skilled artisan, having the originally filed specification would know how to make the applicant's invention as filed is wrong. To emphasize it again, the specification does have an adequate written description how to make the applicant's claimed invention as the preparation of the "basic dispersion" is known to a person skilled in the art.

VIII. CLAIMS

A copy of the claims involved in the present appeal is attached hereto as Appendix A. As indicated above, the claims in Appendix A include the amendments filed by Applicant on March 21, 2006.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 03-2775, under Order No. 13077-00140-US from which the undersigned is authorized to draw.

Dated: October 2, 2007

Respectfully submitted,

Electronic signature: /Ashley I. Pezzner/
Ashley I. Pezzner
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APPENDIX A- CLAIMS APPENDIX

Claims Involved in the Appeal of Application Serial No. 10/057,027

Claim 1. (Previously presented) A dispersion comprising:

polyanions;

cationic 3,4-polyalkyleriedioxythiophenes; and

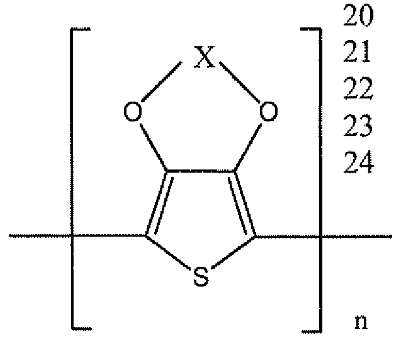
a solvent comprising water and optionally alcohol,

wherein said dispersion has a weight ratio of cationic 3,4-polyalkylene-dioxythiophene to polyanion of from 1: 8 to 1: 25, and 90% by weight of the particles of the dispersion being less than 40 nm.

Claim 2. (Cancelled)

Claim 3. (Cancelled)

Claim 4. (Previously Presented) The dispersion according to Claim 1, wherein the 3,4-polyalkylenedioxythiophenes are represented by formula (I),



(I),

wherein,

n is an integer from 3 to 100, and

X is $-(CH_2)_x-CR^1R^2-(CH_2)_y-$, wherein

R^1 and R^2, independently of one another, are selected from the group consisting of H, an optionally substituted alkyl radical having from 1 to 20 carbon atoms, an aryl radical having from 6 to 14 carbon atoms, and

$-CH_2-0R^3$,

wherein R^3 is selected from the group consisting of H, alkyl and

$-CH_2-CH_2-CH_2-SO_3H$,

and

x and y are each, independently of one another, an integer from 0 to 9.

Claim 5. (Original) The dispersion according to Claim 1, wherein the dispersion is a 3,4-polyethylenedioxythiophene / polystyrene sulfonate dispersion.

Claims 6-8. (Cancelled)

Claim 9. (Previously Presented) The dispersion according to Claim 4, wherein n is an integer from 4 to 15.

APPENDIX B - EVIDENCE APPENDIX

The evidence pursuant to §§ 1.130, 1.131, or 1.132 or entered by or relied upon by the examiner is as follows:

1. Friedrich Jonas Declaration executed May 17, 2005 – First introduced in the amendment filed May 27, 2005

2. Copy of DIN EN ISO 3915 – First introduced in the amendment filed May 27, 2005

3. Friedrich Jonas 1.132 Declaration executed January 11, 2006 – First introduced in the amendment filed January 19, 2006

4. Friedrich Jonas 1.132 Declaration executed January 11, 2006 – First introduced in the amendment filed January 19, 2006

5. http://www.physics.usyd.edu.au/super/life_sciences/FE/FE6.pdf– First introduced in the amendment filed June 20, 2006

APPENDIX C - RELATED PROCEEDINGS APPENDIX

No related proceedings are referenced in II. above, hence copies of decisions in related proceedings are not provided.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Friedrich Jonas et al.
Serial No.:	10/057,027
Filed:	January 24, 2002
Title:	Electroluminescent Arrangements
Art Unit:	1712
Examiner:	Daniel S. Metzmaier

DECLARATION

I, Friedrich Jonas, residing at Krugenofen 15, 52066 Aachen, Germany, declare as follows:

1) That I have the following technical educations and experience:

   a) I am a chemist having studied at the RWTH Aachen, Germany, from 1971 to 1980,

   b) I received the degree of PhD at the RWTH Aachen in the year of 1980,

   c) I am employed by Bayer AG since May 1980 and by H.C. Starck GmbH since December 2001 in the Central Research department, in particular with regard to conductive polymers.

2) that the amendments made to pages 6, 10 and 11 of the specification consist of the same material incorporated by reference relative to EP-A 991 303, in particular: paragraph [0026] of EP-A 991 303 with regard to the amendments to page 6 of the specification; and Beispiel 2 of EP-A 991 303 with regard to the amendments to pages 10 and 11 of the specification.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the pending Application Serial No. 10/057,027 or any patent issuing thereon.

Friedrich Jonas

FRIEDRICH JONAS

Signed at Leverkusen, this 17 day of May 2005

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN ISO 3915

June 1999

ICS 83.080.00

English version

Plastics

Measurement of resistivity of conductive plastics

(ISO 3915 : 1981)

Plastiques – Mesurage de la résistivité des plastiques conducteurs (ISO 3915 : 1981)

Kunststoffe – Messung des spezifischen elektrischen Widerstandes von leitfähigen Kunsstoffen (ISO 3915 : 1981)

This European Standard was approved by CEN on 1999-05-06.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

The European Standards exist in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN ISO 3915 : 1999 E

Foreword

International Standard

ISO 3915 : 1981 Plastics – Measurement of resistivity of conductive plastics,

which was prepared by ISO/TC 61 'Plastics' of the International Organization for Standardization, has been adopted by Technical Committee CEN/TC 249 'Plastics', the Secretariat of which is held by IBN, as a European Standard.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, and conflicting national standards withdrawn, by December 1999 at the latest.

In accordance with the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard:

Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

Endorsement notice

The text of the International Standard ISO 3915 : 1981 was approved by CEN as a European Standard without any modification.

0 Introduction

The method specified in this International Standard is technically similar to that specified for rubber in ISO 1853, *Conducting and antistatic rubbers — Measurement of resistivity*.

However, it differs from that method in certain details, especially those associated with the greater stiffness of the plastic samples, and in particular in the limitation on specimen width. It takes into account two problems encountered in the measurement of resistivity of conductive plastics, namely the sensitivity of these materials to their temperature-history and strain-history, and the difficulty of making adequate electrical contact with them.

The prescribed width of the specimen is mandatory for reference purposes; however, a wider strip may be used, with correspondingly wider electrodes. There is a danger in using a wide strip, if the strip is slightly twisted and at the same time somewhat non-uniform in its resistivity. It is then possible to obtain erroneous results; the potential electrode nearer to the positive current electrode may even be found to be negative with respect to the other potential electrode.

Effect of temperature changes and strain on conductive plastics

As mentioned above, the resistance of these materials is sensitive to their temperature-history and strain-history. The relationships are complex and arise from the kinetic energy and structural configuration of the carbon particles in the polymer.

The resistivity may be increased by the effects of strain produced by (or subsequent to) removal from the mould, and a treatment is described for reducing specimens to a constant strain and temperature condition before measurements are carried out on them. Specimens are also cut in two perpendicular directions to assess anisotropy.

Electrode systems (see 3.3)

Certain types of electrode, when applied to these polymers, have a contact resistance which may be many thousand times greater than the intrinsic resistance of the specimen. Dry contacts under light pressure or point contacts give very high resistances. However, the present test method eliminates the effects of contact resistances unless these are excessively high. (In such a case, no result, rather than a wrong one, is generally obtained.)

1 Scope and field of application

This International Standard specifies the requirements for the laboratory testing of the resistivity of specially prepared specimens of plastics rendered conductive by the inclusion of carbon black. The test is suitable for materials of resistivity less than $10^6\ \Omega\cdot cm$ ($10^4\ \Omega\cdot m$). The result is not strictly a volume resistivity, because of surface conduction, but the effects of the latter are generally negligible.

The principle of the four-terminal method of test is mandatory and the recommended specimen size and electrode design must be adhered to for reference purposes, but it may sometimes be necessary to test a wider strip with electrodes of a different construction.

2 Principle

A stable d.c. current of magnitude (I) is passed between electrodes at the two ends of a strip of the material under test. The voltage drop (ΔU) between two potential electrodes is measured with an electrometer. The resistance of the portion of the strip between the potential electrodes is given by $R = \Delta U / I$, and is independent of contact resistances. Thus the resistivity may be calculated.

3 Apparatus (see figure 1 for schematic diagram of test circuit)

3.1 Current source : a source of direct current which has a minimum resistance to earth of $10^{12}\ \Omega$ (effected by placing it on a highly insulating sheet), and which will not cause a dissipation of power greater than 0,1 W in the specimen.

3.2. Milliammeter or microammeter, as appropriate, for measuring the current to an accuracy of $\pm$ 5 %.

NOTE — Small currents may be computed from measurement of the voltage drop across a known resistance in series with the specimen, using the electrometer (3.4)

3.3 Electrodes

3.3.1 Current electrodes, of clean metal, together with either suitable clamps or grips approximately 5 mm long and extending across the full width of the specimen, or **conductive paint** to cover the same area.

3.3.2 Potentiometric electrode system (see figure 2, for example), having a mass of approximately 60 g so that it exerts a force of approximately 0,6 N on the specimen. The contacts shall normally be 10 ± 0,2 mm apart. For special purposes, the contacts may be further apart (up to 70 mm), but the separation shall be less than the specimen length by at least 60 mm. The distance between the contacts shall be known to an accuracy of ± 2 %. The insulation resistance between the contacts shall be at least 10^{12} Ω.

3.4 Electrometer, having an input resistance greater than 10^{11} Ω and measuring to an accuracy of ± 5 %.

3.5 Sheet of highly insulating material, having a volume resistivity greater than 10^{15} Ω·cm.

3.6 Oven, capable of being maintained at a temperature of 70 ± 2 °C.

4 Specimen

The specimen shall be a strip 10 mm wide and 70 to 150 mm long and shall normally be 3 to 4 mm thick with a tolerance on uniformity of thickness of ± 5 %. Thicker or thinner specimens may be cut from sheets or products. Care shall be taken to avoid bending or stretching the sheets or specimens, especially when they are thinner than standard.

The specimen may be cut with a knife or razor blade, but care must be taken to minimize distortion as this will affect the resistance values.

The surfaces of the specimen shall be clean; if necessary, they may be cleaned by rubbing with fuller's earth (hydrated magnesium-aluminium silicate) and water, rinsing with distilled water and allowing to dry.[1] The surfaces shall neither be buffed nor abraded, nor shall they be cleaned with organic materials that attack or swell the material.

5 Number of specimens

From each of two perpendicular directions, three specimens of equal size shall be prepared and tested. The two directions should, where possible, be chosen to be along and across any direction of flow during processing.

6 Procedure

6.1 After preparation, allow the specimen to remain at room temperature and ambient humidity conditions for at least 16 h.

6.2 Prior to the commencement of the test, connect the current electrodes (3.3.1) to the ends of the specimen, either by using the clamps or grips, or by covering the same area with conductive paint.

6.3 The required conditioning of the specimen should be described in the material specification. If this is not the case, the following procedure will probably be useful in most cases : Immediately after applying the current electrodes, place the specimen on the sheet of highly insulating material (3.5) and heat in the oven (3.6) for 2 h at a temperature of 70 ± 2 °C to remove strains and irregularities caused by previous treatment. Cool for at least 1 h and test at 23 ± 2 °C and 50 ± 5 % relative humidity without disturbing the specimen. The specimen shall always be tested on the sheet of insulating material. With some materials, distortion may occur at 70 °C and heating for 5 h at 60 ± 2 °C may then be preferable.

6.4 Place the potentiometric electrode system (3.3.2) on the specimen, ensuring that the knife-edge contacts are at right angles to the direction of current flow and that neither potentiometric electrode is within 20 mm of a current electrode. Apply the current and measure the voltage drop between the potentiometric electrodes using the electrometer (3.4).

Repeat the measuring procedure twice more on the same specimen, moving the potentiometric electrodes each time to obtain measurements over lengths of specimen evenly distributed between the current electrodes.

6.5 Test the other five specimens similarly.

7 Expression of results

7.1 Calculate the resistance R, in ohms, corresponding to each position of the potentiometric electrodes, using the formula

$$R = \frac{\Delta U}{I}$$

where

ΔU is the voltage drop, in volts, between the potentiometric electrodes;

I is the current, in amperes, through the specimen.

7.2 The resistivity ϱ, expressed in ohm centimetres, is given by the formula

$$\varrho = \frac{R \times A}{d}$$

where

R is the resistance, in ohms, calculated in accordance with 7.1;

A is the cross-sectional area, in square centimetres, of a specimen perpendicular to the current flow (see figure 3);

1) If a particular drying method is necessary, it should be stated in the material specification.

d is the distance, in centimetres, between the potentiometric electrodes.

For each direction of current flow, determine the median of the nine resistivity values thus calculated.

8 Test report

The test report shall include the following particulars :

a) reference to this International Standard;

b) complete identification of the sample, including processing details if relevant;

c) dimensions of the test specimen;

d) conditioning, if different from that described in 6.3, or if the 60 °C conditioning is used;

e) the distance between the potentiometric electrodes;

f) the average value of voltage drop measured;

g) the individual resistivity values and the medians of the results in the two directions of test;

h) any other details that may have had an effect on the test results.

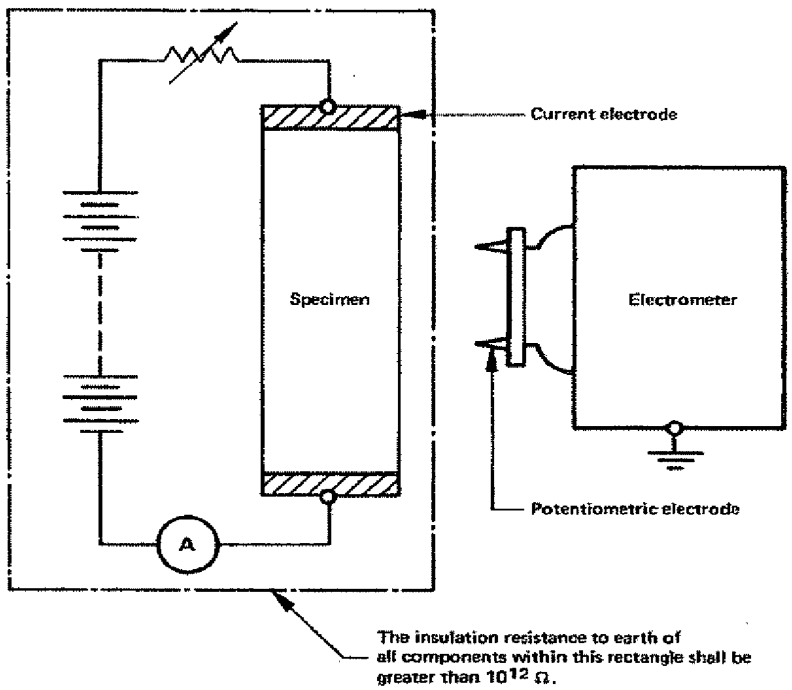


Figure 1 — Schematic diagram of test circuit

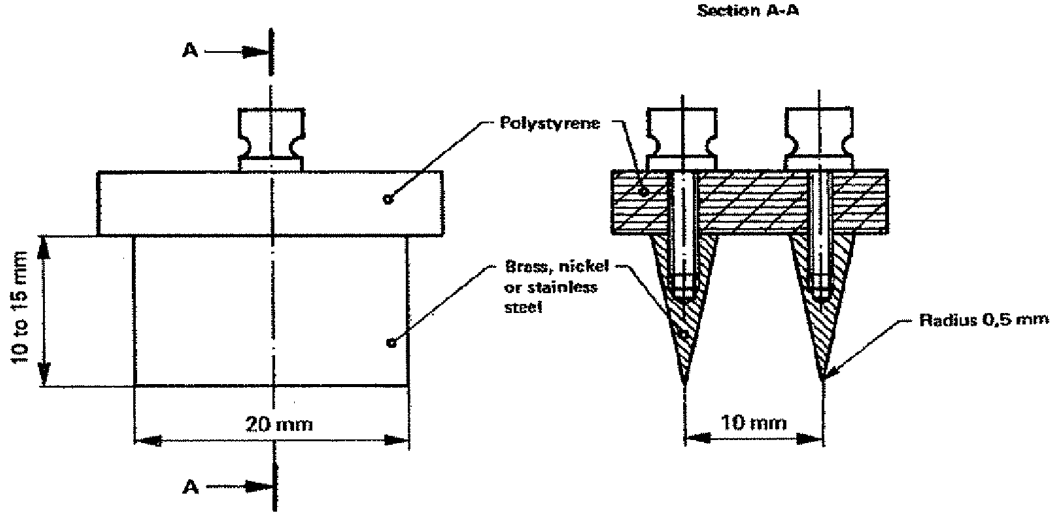


Figure 2 — Potentiometric electrodes

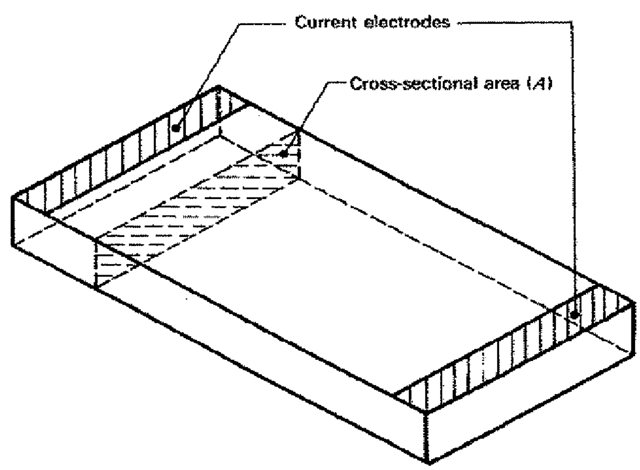


Figure 3 — Test specimen

PATENT APPLICATION
Mo-6935
LeA 34,765

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION OF FRIEDRICH JONAS ET AL	GROUP NO.: 1712
SERIAL NUMBER: 10/057,027	EXAMINER: DANIEL S. METZMAIER
FILED: JANUARY 24, 2002	
TITLE: ELECTROLUMINESCENT ARRANGEMENTS	

DECLARATION UNDER 37 C.F.R. §1.132

I, Dr. Friedrich Jonas , residing at Krugenofen 15Aachen, Germany, declare as follows:

1) that I have the following technical educations and experience:

a) I am a chemist having studied at the RWTH Aachen, Germany, from 1971 to 1980

b) I received the degree of PhD at the RWTH Aachen in the year of 1980 .

c) I am employed by Bayer AG in the central research department since May 1980 and by H.C.Starck since 2001 in particular with regard to conductive polymers .

2) that the following tests were carried out under my immediate supervision and control:

From a Baytron® P Al 4083 PEDT solution and a polystyrene sulphonate solution a PEDT/PSS dispersion was prepared in such a way that the PEDT/PSS ratio of the resulting dispersion was 1:20. The particle size distribution of the dispersions was, in each case, measured before and after homogenization, by means of an ultracentrifuge method in accordance with that described at page 4, lines 4-6 of the specification

Coatings were subsequently produced on glass plates by spin coating followed by drying at 120°C. The resitivity of the resulting layers was determined under reduced pressure at a pressure of about 10^{-6} mbar.

The results so obtained are summarized in the following table.

Homogenization	None	2 times at 400 bar	4 times at 400 bar
90 wt.% of the particles in the dispersion in the swollen state < x nm	55	53.8	34.3
Resisitivity [Ωcm]	17,400	76,000	130,000

I further declare that all statements made herein are of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States code and that such willful false statements may jeopardize the validity of pending Application Serial Number 10/057,027 or any patent issuing thereon.

Signed at Leverkusen this 11th day of January, 2006

Fried. R.

Inventor name

APPENDIX-(II)

Declaration of Dr. Friedrich Jonas

Including particle size distribution data obtained from a dispersion prepared in accordance with Example 1 of Krafft et al.

PATENT APPLICATION
Mo-6935
LeA 34,765

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION OF	) GROUP NO.: 1712
FRIEDRICH JONAS ET AL	)
SERIAL NUMBER: 10/057,027	) EXAMINER: DANIEL S. METZMAIER
FILED: JANUARY 24, 2002	)
TITLE: ELECTROLUMINESCENT ARRANGEMENTS	)

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b) I received the degree of PhD at the RWTH Aachen in the year of 1980 .

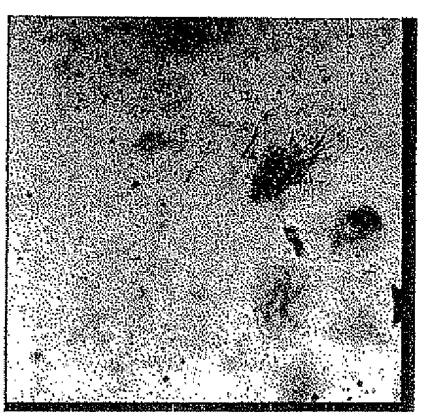
c) I am employed by Bayer AG in the central research department since May 1980 and by H.C.Starck since 2001 in particular with regard to conductive polymers .

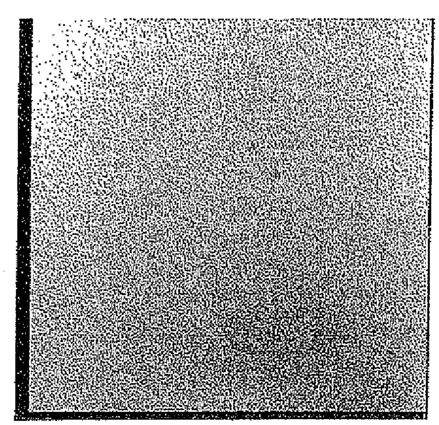
2) that the following tests were carried out under my immediate supervision and control:

A polyethylenedioxythiopnene / polystyrenesulfonate (PEDT / PSS) dispersion (having a theoretical ratio of PEDT : PSS of 1:3,6) was prepared according to Example 1 at column 9, line 60 through column 10, line 59 of United States Patent No. 5,370,981 **(Krafft et al)**. One drop of the dispersion was placed on a glass microscope slide, and a photomicrograph was taken thereof at a magnification of 100X (Picture-1). Upon visual observation of Picture-1, the presence of coarse particles having sizes in excess of 100 micrometers (100,000 nanometers) is evident. A dispersion containing such coarse particles would lead to short circuits if used to prepare a hole injection layer in an organic electroluminescent devise (e.g., as described in Applicants' present patent application, U.S. Pat. Application No. 10/057,027, referred to herein as "Mo-6935").

The comparative dispersion prepared in accordance with Example 1 of Krafft et al was found to have a d_{40} particle size of 62.6 nanometers, and a d_{90} particle size of 3156 nanometers. The particle sizes being measured by a ultracentrifuge method in accordance with that described at page 4, lines 4-6 of Applicants' specification.

For purposes of comparison, a photomicrograph (Picture-2) of a PEDT / PSS dispersion according to Mo-6935 (having a ratio of PEDT : PSS of 1:20, and a d_{90} of 34,9 nm) was obtained in substantially the same manner as Picture-1. At a magnification of 100X, no coarse particles of 100 micrometers or greater are observed.





I further declare that all statements made herein are of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States code and that such willful false statements may jeopardize the validity of pending Application Serial Number 10/057,027 or any patent issuing thereon.

Signed at Leverkusen this 11th day of January, 2006.

Inventor name

http://www.physics.usyd.edu.au/super/life_sciences/FE/FE.pdf

FE6 ROTATION

OBJECTIVES

Aims

A careful study of this chapter should equip you with a basic understanding of the concepts and principles used to describe rotational motion. You will learn how to apply these ideas to fairly simple cases where things rotate about an axis whose direction in space remains fixed. You should understand the idea of a frame of reference and the kinds of modifications to physical theory which are adopted in order to cope with situations observed from an accelerating frame of reference.

Minimum learning goals

When you have finished studying this chapter you should be able to do all of the following.

1. Explain, interpret and use the terms
   angular velocity, angular acceleration, centripetal force, translational kinetic energy, rotational kinetic energy, frame of reference, pseudoforce, centrifugal force, centrifuge, ultracentrifuge.
2. Solve simple problems on uniform circular motion involving centripetal force, centripetal acceleration, mass, radius, speed and angular velocity.
3. Explain how the total kinetic energy of a rigid body can be expressed as the sum of translational and rotational kinetic energies and apply this result to simple problems.
4. Explain why and how the equation of motion for an accelerating frame of reference is modified by including pseudoforces
5. State and apply the formula for centrifugal force in terms of mass, angular velocity and radius.
6. Explain the operating principles of the centrifuge and ultracentrifuge.

PRE-LECTURE

The theme of this chapter is rotation. We shall examine two quite different aspects. Firstly, extending the discussion on energy in the previous chapter, we shall look at the kinetic energy of rotating objects. Secondly, we shall look at the centrifuge. In order to talk about the centrifuge, we digress and see how the equation of motion may be written in different frames of reference; in particular, how it may be written in a rotating frame of reference.

6-1 CIRCULAR MOTION

Consider a small object moving with constant speed v in a circle of radius R.

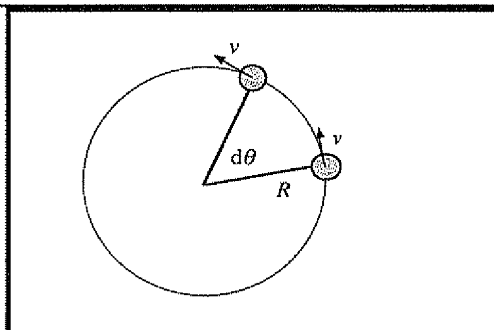


Figure 6.1 Circular motion

In a short time interval $\mathrm{d}t$ it sweeps out an angle $\mathrm{d}\theta$. The **angular velocity** of the object is defined to be

$$\omega = \frac{\mathrm{d}\theta}{\mathrm{d}t} . \qquad \text{... (6.1)}$$

The angular velocity and the speed of the object are connected by the relation

$$\omega = \frac{v}{R} . \qquad \text{... (6.2)}$$

If the angular velocity changes with time the object also has an **angular acceleration**:

$$\alpha = \frac{\mathrm{d}\omega}{\mathrm{d}t} . \qquad \text{... (6.3)}$$

The SI unit of angular velocity is the radian per second, symbol $\mathrm{rad.s^{-1}}$. The unit of angular acceleration is radian per second per second, $\mathrm{rad.s^{-2}}$.

6-2 ROTATION OF A RIGID BODY ABOUT A FIXED AXIS

The reason for introducing these angular variables is to simplify the description of rotating bodies. If a rigid body rotates about an axis which is fixed in space, then different parts of the body have different linear velocities and accelerations. On the other hand, all the particles in the body have the same angular velocity and the same angular acceleration. This description in terms of angular variables is useful even if the axis of rotation moves.

Q6.1 In chapter FE1 we quoted the result that the centripetal acceleration of an object moving with speed v in a circular path was equal to $\frac{v^2}{R}$. Re-express this in terms of angular velocity. (We need this result later.)

Preparation

Read the sections in chapter FE3 about rotational motion and moments of inertia. Revise questions 2.4 and 2.6(b) in FE2.

LECTURE

6-3 ROTATIONAL KINETIC ENERGY

When a rigid body is rotating about a fixed axis, different parts of the object move with different speeds. Parts near the edge have greater speeds than those near the axis of rotation. Consider one small part of the object, with mass Δm, moving at speed v. Its kinetic energy is $\frac{1}{2}(\Delta m)\, v^2$, so the total kinetic energy of the whole body is the sum of the kinetic energies of all its parts, which we can write as $\sum \frac{1}{2}(\Delta m)\, v^2$. Note that there will be many different values of v in this sum. However, by using the common angular velocity, ω, instead of speed we can write a simple formula for the **rotational kinetic energy**:

$$\mathrm{KE} = \frac{1}{2} I\omega^2 \qquad \text{... (6.4)}$$

where I is the moment of inertia of the object, mentioned in chapter FE3. The moment of inertia depends on the distribution of mass in the body. If you consider two objects with the same total mass, the one with more of its mass further from the axis of rotation has the higher moment of inertia. Note also that a body does not have a unique moment of inertia; the value of I depends on the location of the axis of rotation.

In general a rigid body (e.g. a boomerang) has both rotational and translational motion. Each part still has kinetic energy $\frac{1}{2}(\Delta m)\, v^2$, but some of that energy is now associated with the motion of the body as a whole and the rest of it is associated with the rotational motion. Consequently the total kinetic energy of the body can be expressed as a sum of **translational kinetic energy**, associated with the motion of the centre of gravity of the body, and kinetic energy of rotation. Provided that the body is rigid and that its axis of rotation through the centre of gravity stays in the same direction in space, the total KE can be written in the simple form:

$$\text{total KE} = \frac{1}{2} m v_C^2 + \frac{1}{2} I\omega^2 ,$$

where v_C is the speed of the centre of gravity and m is the total mass of the body.

Demonstrations

- A block of dry ice slides down a slope more quickly than a round object rolls down the slope. Gravitational force does work on the objects. All the PE of the sliding object is converted into KE of translation. But the PE of the rolling object must be shared between KE of translation and KE of rotation which means that the translational motion takes only a fraction of the total KE. (The value of that fraction depends on the shape of the body, but not its size.) At a given distance down the slope, the speed of the centre of gravity must be less for the rolling object.
- A sphere rolls more quickly than a solid cylinder which in turn rolls more quickly than a hollow cylinder, even though all three objects have equal radii. This happens because the mass is distributed differently in each object and the sharing between the KE of translation and the KE of rotation is different.
- In a model car energy is stored as rotational KE of a flywheel. It is converted into translational KE of the car and eventually into non-mechanical energy which is lost from the system.

6-4 ACCELERATED FRAMES OF REFERENCE AND PSEUDOFORCES

Frames of reference

If you want to describe the motion of an object you need a coordinate system, or something equivalent, to which you can relate your measurements of position; it doesn't make sense to give position coordinates (x, y, z) unless you know where the origin is and the directions of the axes. Specifying the origin and the axes is a formal, but somewhat abstract, way of describing a **frame of reference**. In practice a frame of reference is anchored to some physical objects, and when we talk about an observer we imagine a person at rest in his or her own reference frame. We now explore some aspects of how the choice of a reference frame can affect the observed motions of objects and even the laws of motion themselves.

Demonstration: Acceleration in a straight line

- A truck is moving at constant velocity (figure 6.2). An object is dropped and is seen to fall to a point on the floor of the truck, directly below the point of release. To an observer in the truck's frame of reference, the object falls vertically along a straight line path. The truck's frame of reference is not accelerating, and nothing unusual occurs.

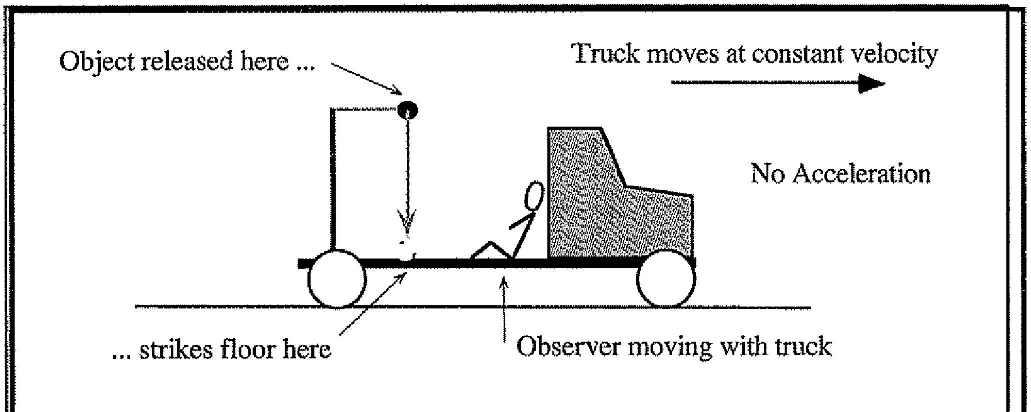


Figure 6.2 Dropping an object in a moving frame of reference
The frame of reference attached to the truck is moving with constant velocity.

- In the second part of the demonstration the object is dropped while the truck is slowing down to stop (figure 6.3).

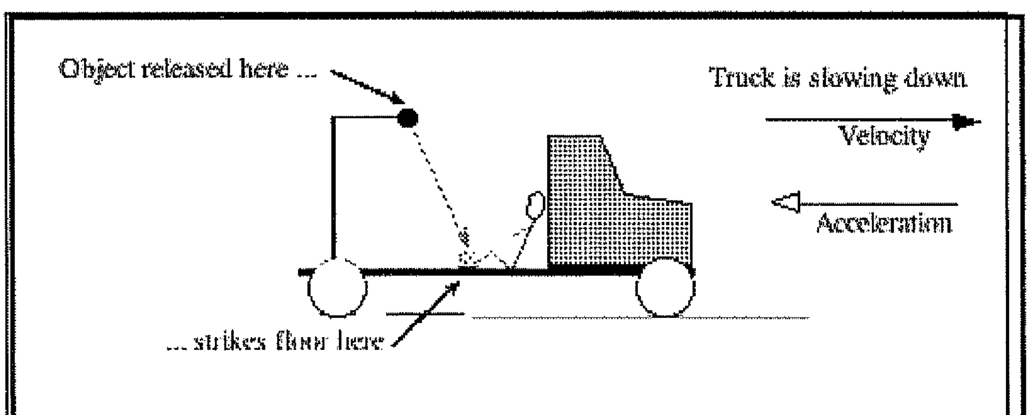


Figure 6.3 Dropping an object in an accelerated frame

In this case the truck and its frame of reference are accelerating. To an observer in the truck's frame of reference it looks as if there is a force pushing the object forward as it falls. The observer cannot explain this using the equation of motion. There is no known kind of forward force to

account for the path of the falling object. The problem can be resolved by introducing a **fictitious force**, or **pseudoforce**, to make the equation of motion work in the accelerated frame of reference.

Demonstration: Measurement of weight in a lift

A body is weighed in a lift. (This problem was described in Q2.10, FE2, where a fixed frame of reference, outside the lift, was used.) If the frame of reference is attached to the accelerating lift, then the forces on the body being weighed are the gravitational force, the supporting force exerted by the platform of the scales, plus a pseudoforce, associated with the accelerated frame (figure 2.11). The supporting force, whose magnitude is equal to the apparent weight recorded on the scales depends on both the gravitational force and the pseudoforce.

Motion in a circle

Imagine an object which has a string tied to it and is swung around in an approximately horizontal circular path (figure 6.4). Think of an imaginary observer riding on the object. The frame of reference for this observer is accelerating. Now the observer knows that the string exerts a force to the left, but cannot explain why the object does not go off in that direction, although the equation of motion predicts that it should. To make the equation of motion work the observer introduces a pseudoforce - in this case a force to the right in order to counteract the force exerted by the string.

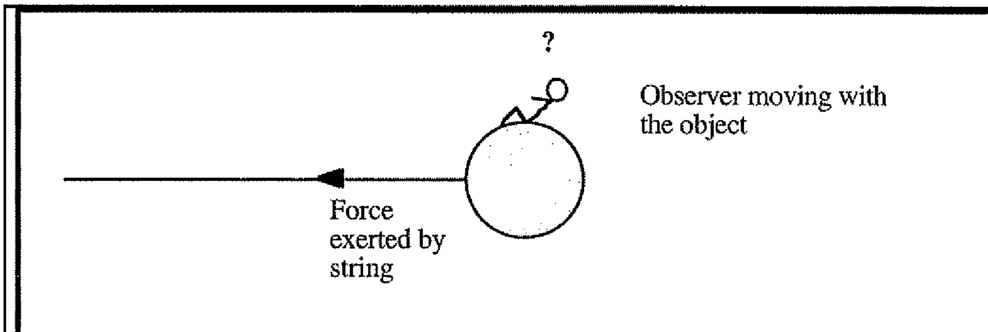


Figure 6.4 Observer in a rotating frame of reference

We know from our bird's eye view of the object moving in the circle that the force exerted by the string is equal to $m\omega^2R$. Therefore the moving observer's pseudoforce must also be equal to $m\omega^2R$, but it is in the opposite direction - outwards. This kind of pseudoforce is often called **centrifugal force.**

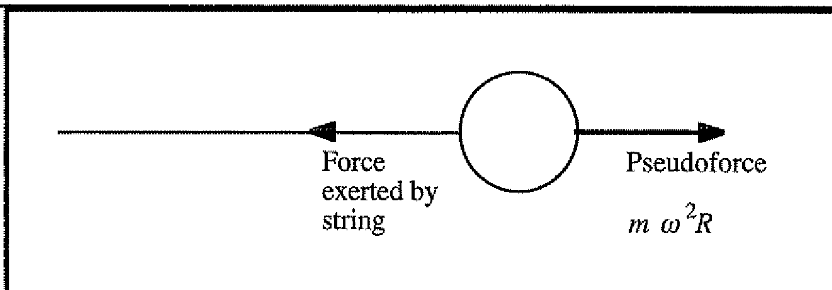


Figure 6.5 Forces in a rotating frame

In summary, the equation of motion works properly only in a frame of reference that is not accelerating. However it is often convenient, from the point of view of mathematical simplicity, to use an accelerated reference frame and non-physical pseudoforces which are invented only in order to preserve the equation of motion. We say that the pseudoforces are non-physical firstly because they violate the law that forces always occur in pairs and secondly because it is not possible to identify a physical object which is the source of the force.

6-5 THE CENTRIFUGE

The **centrifuge** is used extensively to separate materials of differing densities. A tube containing the materials swings around the axis of the centrifuge at a high angular velocity (figure 6.6).

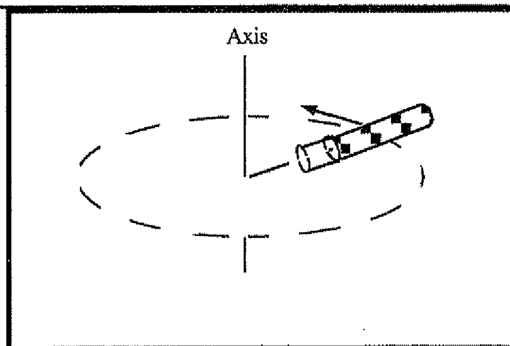


Figure 6.6 Principle of the centrifuge

If a suspended particle is going to remain at a given radius as the centrifuge rotates, the forces on it due to the surrounding material must combine to provide a centripetal force $m\omega^2R$. If the surrounding material cannot provide sufficient force the particle moves to a greater radius where the surrounding material or the bottom of test-tube can provide the necessary centripetal force. (See figure 6.7.)

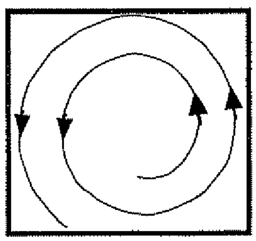


Figure 6.7 Path of a particle in a centrifuge
This is a bird's eye view of the path. The particle moves to greater radius

Our discussion of the centrifuge can be greatly simplified by looking at things from the point of view of an imaginary observer who rides around with the test tube rather than from a bird's eye view. An observer riding around with the tube in the centrifuge is accelerating so we can use the equation of motion ($F = ma$) only by introducing a fictitious centrifugal force.

Consider the motion of a suspended particle as described in the accelerated frame of reference. In figure 6.8 the force to the left is provided by the surrounding material.

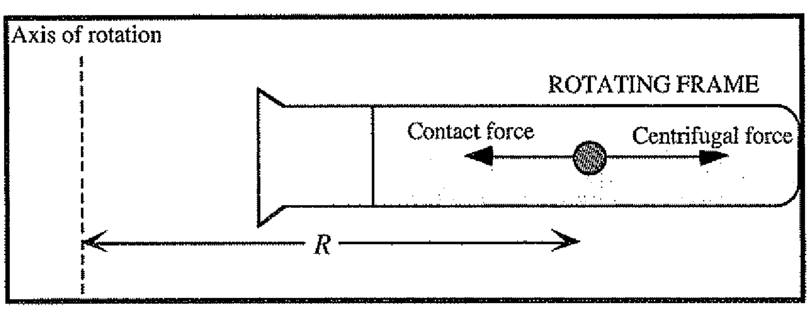


Figure 6.8 Real force and pseudoforce on a particle in a centrifuge
In this case the particle is suspended at a fixed radius, so it is at rest in the rotating frame. The centrifugal force is a pseudoforce. The buoyant-like contact force is a real pressure force exerted by the surrounding fluid

The pseudoforce is still equal to $m\omega^2R$. If the real contact force provided by the surrounding material is less than or equal to $m\omega^2R$ then the particle moves further down the test-tube. The centrifugal pseudoforce is rather like a gravitational force which causes suspended particles to settle out. By making the angular velocity (ω) very high the pseudoforce ($m\omega^2R$) can be 10^4 to 10^5 times greater than the weight of the particle. So we can ignore the weight, giving a total force along the radius. Seen from the rotating frame, the motion of a particle that starts from rest will therefore be a straight line, not the spiral seen by the outside observer.

6-6 THE ULTRACENTRIFUGE

The ultracentrifuge in the Department of Biochemistry is often used to measure the molecular weights of protein molecules. The rotor shown in the lecture runs at speeds up to 60 000 revolutions per minute giving a maximum centrifugal force of 260 000 times that of gravity. Rotors for ultracentrifuges must be carefully designed so that they do not fly apart under the large centrifugal forces. These considerations set a limit on the radius of a rotor and its speed of operation. The chamber containing the rotor is evacuated to eliminate heating due to air friction.

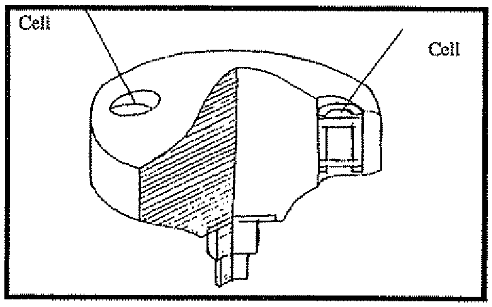


Figure 6.9 An ultracentrifuge rotor
A cut-away view showing the location of cells containing protein samples.

In this case, the particles of interest are very small - small enough for diffusion to occur; so they are also small enough to be influenced by the forces exerted by individual liquid molecules rather than by the 'averaged out' forces (the drag and the buoyant forces). Sedimentation of the protein molecules cannot take place under gravity because their weight is not sufficient to overcome their diffusion upwards. If we centrifuge the sample, we can increase the speed of rotation until the centrifugal (pseudo) force overcomes the diffusion and drives the protein molecule to a greater radius.

The molecular weight of the protein molecules is determined from the sedimentation rate, the density of the molecules and the density of the surrounding fluid. Diffusion effects must be subtracted out. The size of the diffusion effects is obtained from measurements of the sedimentation rate taken at different speeds of rotation.

The measurements are all made while the sample is spinning around inside the machine. This is the difference between an analytical ultracentrifuge and the ordinary type of centrifuge which is used for separation. The radial movement of the protein molecules is monitored by optical techniques. Use is made of the fact that the refractive index of the protein molecules is different from that of the surrounding liquid.

6-7 CORIOLIS FORCE

Another kind of pseudoforce, the Coriolis force, appears in a rotating frame of reference. A demonstration shows a two-dimensional version of the Coriolis effect. A container moving along a straight path drops sand onto a rotating platform. The track of the falling sand in the frame of the

platform is a curve rather than a straight line. To explain this curved path another fictitious force, the Coriolis force, can be introduced.

A similar effect occurs with global wind patterns. Air masses moving towards the equator are deflected from a true south-north path because the Earth rotates underneath. In a rotating frame attached to the Earth's surface, the winds appear to be deflected. In order to preserve the equation of motion in the rotating frame we invent two fictitious forces - centrifugal and Coriolis.

POST-LECTURE

6-8 QUESTIONS

Rotation

Q6.2 A gramophone record is rotating at a rate of 33 1/3 revolutions per minute. What is its angular velocity in rad.s^{-1}?

Q6.3 The dental drill probably reaches higher speed than any other production micro-mechanism. The angular speed is about 60 000 rad.s^{-1}. If the dental burr has a diameter of 1.5 mm, how fast is the outside of the burr moving?

Rotational kinetic energy

Q6.4 A flywheel is rotating with an angular velocity of 5 revolutions per second. What does its angular velocity become when its rotational kinetic energy increases 16 times?

Q6.5 Could a sphere roll down a slope if friction were absent?

Q6.6 How can you tell the difference between a raw egg and a hard-boiled egg by spinning them?

Accelerated frames of reference and pseudoforces

Q6.7 Refer to the demonstrations of motion observed in a frame of reference attached to a moving truck.

a) If the truck were speeding up (figure 6.10) where would the object strike the floor?

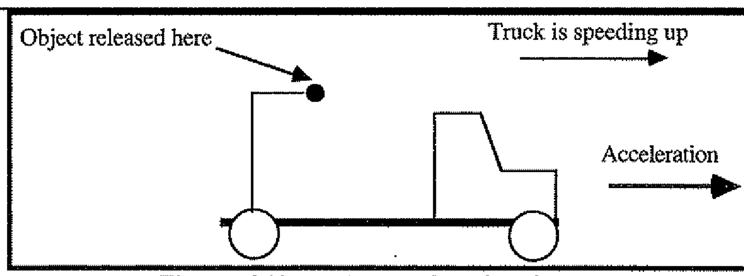


Figure 6.10 An accelerating frame
What happens to the falling object?

b) Can an observer standing at the side of the road explain the motion using the equation of motion? (Or does the observer need to invoke pseudoforces?)

Q6.8 Discuss the way you are thrown around in a car when it stops suddenly and when it turns a corner sharply

i) from the point of view of a bird watching from its perch on a power line, and

ii) from the point of view where all measurements are made with respect to the car.

6-9 MORE ABOUT THE CENTRIFUGE

The centrifuge is used to increase the settling speed of particles which fall very slowly through the surrounding liquid. (See §4-5 on *Sedimentation*). In a frame of reference rotating with the test-tube the horizontal forces on a typical particle are as shown in the horizontal plan view in figure 6-11. In comparison with these forces, the vertical forces on the particle are very small and may be neglected. (The Coriolis force can also be neglected in this argument.) The two forces acting to the left are exerted by the surrounding liquid. The drag force is the same as that introduced in FE4. The

'buoyant-like' force is the analogue of the familiar buoyant force - its magnitude is independent of the motion of the particle relative to the liquid. Both are real forces.

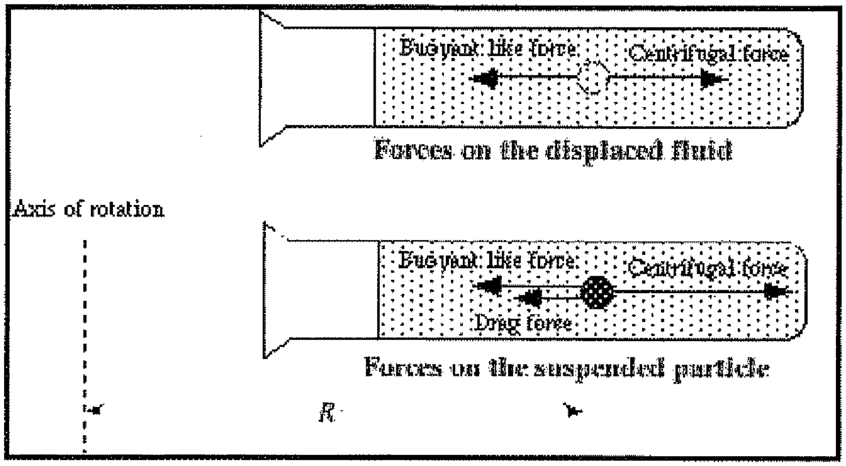


Figure 6.11 Real forces and pseudoforce on a particle in a centrifuge
Here the particle is moving 'down' the tube to the right. The 'buoyant like' contact force and the drag force, both exerted by the fluid, are real forces. The centrifugal force is a pseudoforce.

The magnitude of the buoyant-like force can be found by the method used for the buoyant force in FE3. Consider the forces which would act on a portion of fluid, mass m_L, corresponding to the liquid displaced by the particle. See the upper part of figure 6.11. Since this portion of liquid does not move along the radius (why?), the 'buoyant like' force balances the centrifugal force $m_L \omega^2 R$. Using ρ_L to denote the density of the liquid and V for the common volume of the particle and the displaced liquid we get:

$$\text{buoyant-like force} = m_L \omega^2 R = \rho_L V \omega^2 R.$$

Returning to the forces on the suspended solid particle (lower diagram in figure 6.11), the buoyant like force on the particle is equal to that on the displaced liquid. (Why?) Also

$$\text{centrifugal force on the particle} = \rho V \omega^2 R \ ,$$

where ρ is the density of the particle.

The terminal velocity is the velocity at which the drag force λv balances the other forces acting. So the equation of motion for the suspended particle becomes:

$$\rho_L V \omega^2 R + \lambda v_T = \rho V \omega^2 R.$$

We can rearrange this to get an expression for the settling speed:

$$v = \frac{V}{\lambda}(\rho - \rho_L)\, \omega^2 R.$$

Compare this with the equation for gravitational settling worked out in §4-5 :

$$v_T = \frac{V}{\lambda}(\rho - \rho_L)\, g \ .$$

The angular speed ω of the centrifuge can be increased to make the centripetal acceleration, $\omega^2 R$, very much greater than g and to provide very much greater settling speeds.

Q6.9 A general laboratory centrifuge rotates at its maximum angular speed of 8 000 revolutions per minute. Consider a particle at a rotation radius of 110 mm.

a) Compare the centrifugal force on the particle with its weight.

b) In Q4.1, FE4, the sedimentation rate for a particle settling under gravity was several millimetres per hour. What would the sedimentation rate be if this centrifuge were used?

SUMMARY: GRAPHICAL PRESENTATION OF INFORMATION

The table below shows how slopes and areas of various kinds of graphs can be used to calculate values of physical quantities.

Ordinate ('y')	**Abscissa ('x ')**	**Slope**	**Area between curve and 'x' axis**
distance travelled	time	speed	--------
displacement*	time	velocity*	--------
speed	time	---------	distance travelled
velocity*	time	acceleration*	displacement*
acceleration*	time	---------	change in velocity* (v)
total force*	time	-----------	mass × (change in velocity*)
force*	displacement*	---------	work
conservative force*	displacement*	---------	- (change in potential energy)
potential energy	displacement*	-(conservative force*)	------------